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Strategies for MainStreaming Grid-Connected PV *This Decade*

NREL; March 26, 2003

Daniel Shugar, P.E.
President

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PowerLight Corporation Overview

- PV Sys Manufacturer & Solutions Provider
  Focus: Commercial / Industrial / Utility
- Founded ’91 in Bay Area, Global Offices
- Partnership Based Business Model

- High internal growth
  1) 2x each year since 1997
  2) “Inc. 500” last 3 Years
- Profitable since inception
- Grid-Tied Leader; Largest PV module customer in America

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Selected PowerLight Thin-Film Projects: 1994 to 2003

600 kW UniSolar
Bakersfield, '02

30 kW First Solar
Rhode Island, '00

100 kW BP a-Si
Raleigh, NC '02

3 kW APS
Folsom, CA '94

270 kW BP Apollo
Dublin, CA, '01/'02

42 kW BP a-Si
Cape Charles, VA '98

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Selected PowerLight Crystalline Projects

800 kW S.R. Jail: CA '01

500 kW FTB: CA '02

500 kW Toyota: CA '03

1 MW US Navy: CA '02

500 kW
Neutrogena, CA '01

500 kW Mauna Lani, HI '98 –'02

650 kW
Janssen, NJ '03

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Topic of Day

- Prof Margolis says we need $4-$11B to achieve $3/W
- Accept it – reasonable assumptions, solid methodology
- Soooo … where do we find $7.5B, +/-$3.5B?
- Alternatively, how to grow demand to lower cost?
- What are implications for R&D priorities?

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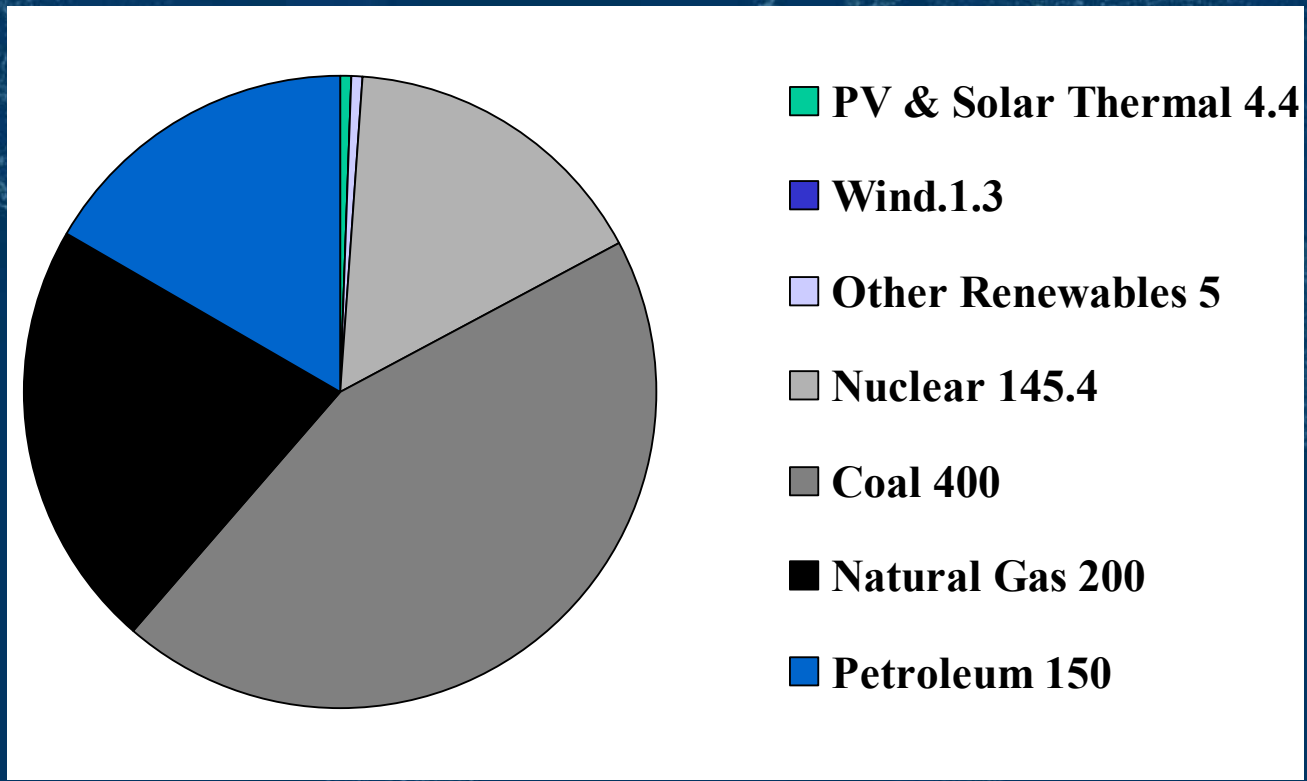
Federal Support for Energy Sources; 1943-1999, $B



By Contrast:

Gulf War 1: $100B

Gulf War 2: $74-300B

World Trade Ctr: $110B

Afgan War: $100B

Homeland Security: $37B

Source: Renewable Energy Policy Project, Research Report 11, "Federal Energy Subsidies: Not All Technologies Are Created Equal," MRG & Associates, an environmental and economics consulting firm, Madison,WI. July 2000.

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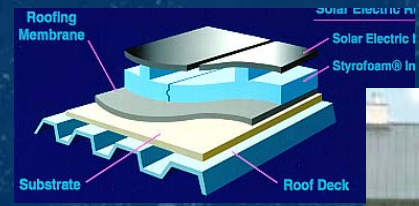
Objective Function for Maximum Value

PV Benefits

- Tracker: +25% kWh
- PV Roofing
- PV Demand Reduc.
- PV+Efficiency



PV Costs

- 50% Module
- 50% BOS/Engr/Install/O&M

Module costs only ¼ of Equation!

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Flashback: 1994 IEEE Specialists Conference

Tom Dinwoodie
PowerLight

Dan Shugar
Advanced Photovoltaic Systems

Optimizing Roof-Integrated Photovoltaics: A Case Study of the PowerGuard Roofing Tile

a-Si PowerGuard System

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Thin-Film vs Crystalline; Time for a status check

Over the last 10 years:

1. **Solar grade silicon prices have dropped by 10X**
2. **Thin-film commercialization has slipped**
3. **Crystalline technologies have improved dramatically; sustained progress likely**

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Selected PV Integration Considerations

1. Efficiency (5 to 15 watts / square foot)
2. Frame or Frameless (Up to $20/module)
3. Mechanical Size
4. Mechanical Strength (tempered vs annealed)
5. Operating Voltage & Fusing Requirements
6. Color
7. Reflectivity
8. Fire Rating (Class A, B, or C)
9. Size of Project for to Maximize Revenue

Note: The least expensive PV module in $/watt often does not result in the least expensive PV system in $/watt

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Integration Considerations for PV Modules > 40 watts

		Thin-Film (Glass Substrate)	Crystalline Technologies	Approx. Sys. Cost Impact to Thin-Film
1	*Module Power (to Edge)*	4 to 7 W/Ft^2	10 to 15 W/Ft^2	$0.30/W - $1.25/W
2	*Mechanical Strength*	Annealed/ Heat Strengthened	Tempered (5 to 10X stronger)	$0.06/W - $0.30/W
3	*Lamination QA/QC*	Poor	Good	*Included in #2*
4	*Module O.C. Voltage*	45V to 100V typ.	20V to 50V typ.	$0.03/W - $0.33/W
5	*Typical 'String' Power*	200W to 750W	1500W to 3000W	*Included in #4*
6	*Stability*	Poor	Good	$0.30/W - $0.60/W
7	*Voltage Isolation*	Intermittent	Excellent	*Included in #6*
8	*Module Design Flex.*	Poor	Excellent	*Not quantified*
9	*Blocking Diode Req'd*	Yes	No	$0.02/W - $0.05/W
10	*Opaque to UV?*	No	Yes	$0.00/W - $0.10/W
11	*End of Life Recycle?*	Some	No	$0.00/W - $0.20/W
	Avg cost impact:	*$1.77/Wp*	*TOTAL:*	*$0.71/W - $2.83/W*

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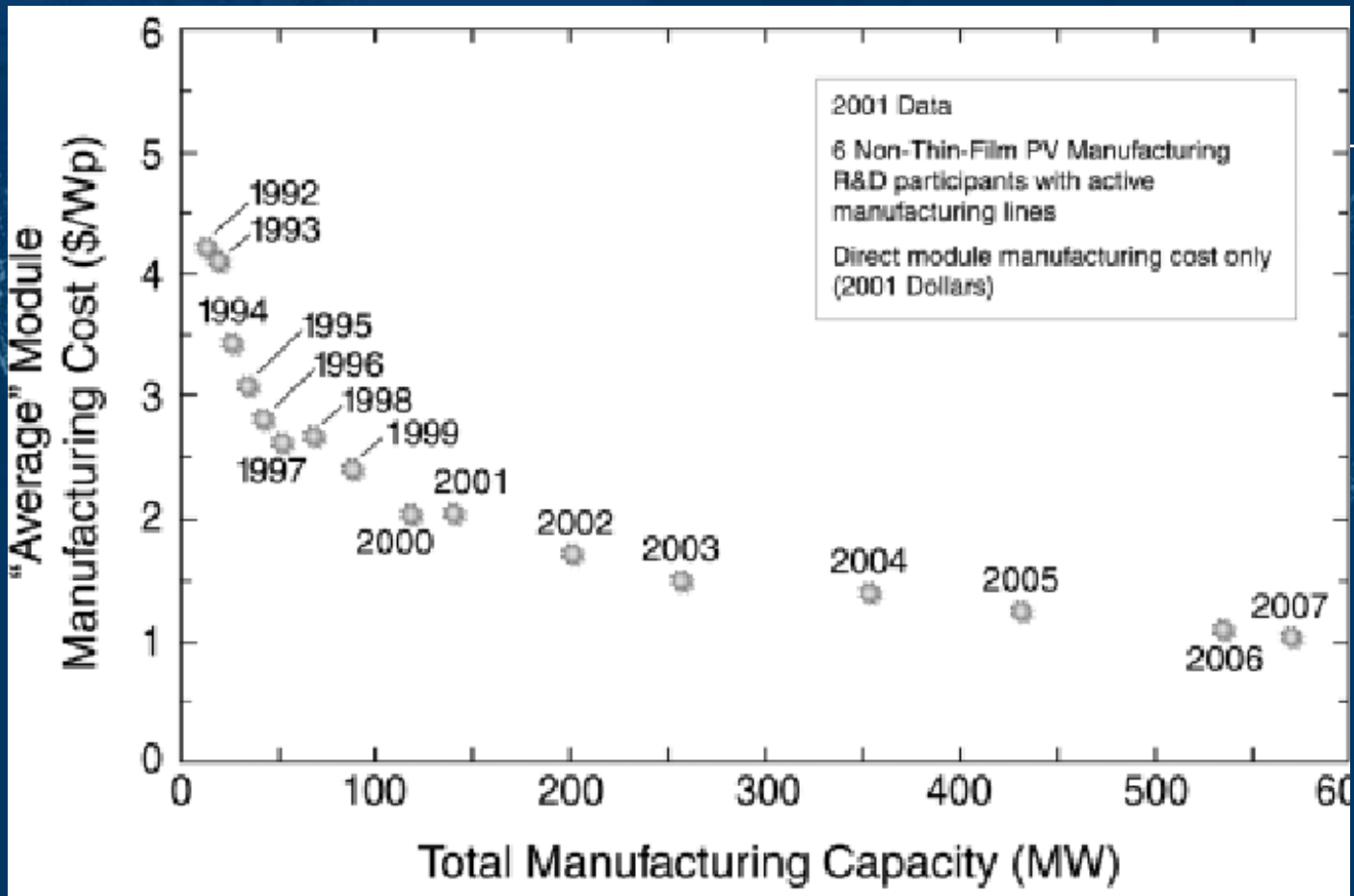

Fig. 2. Non-thin-film PVMaT manufacturing cost/capacit
(2001 data using 2001 dollars).

Source:
Rick Mitchell, NREL
29th IEEE PVSC

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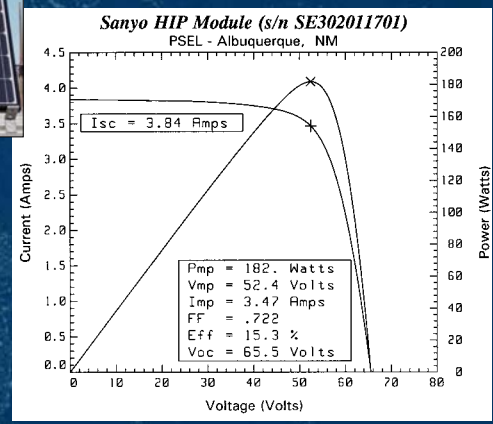
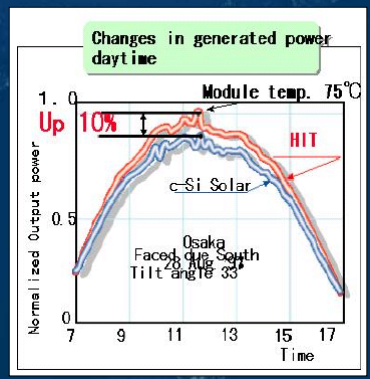
Crystalline Progress Example: Sanyo HIT Technology

- 175W Module: *17% cell/15% module*
- 190W Module: *18% cell/16% module*
- No L.I.D. *(normally ~2.5%) or S.W. Degradation*
- Excellent Temp Coeff.
- 200 micron wafer
- Proven in Large Systems
- Substantial New Capacity Planned





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Bridging the Gap

Policy

- Advocate PV Benefits = Incentives & RPS w/DG

  Ex. PV-Now (National Advocacy/lobbying group, SEIA Subcommittee)

Need to Balance R&D investments:

- Balance *PV modules* with *Systems Technologies*
- Balance *Near-term PV (crystalline)* with *Long-Term PV*
- Focus on *Benefits* as well as *Cost* and *Performance*


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SOLAR ELECTRIC SYSTEMS